Plant–microbe mechanisms & responses to environmental stressors on urban green roofs

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Introduction

Extreme climate events such as heatwaves and droughts are predicted to increase in frequency in the northeastern United States. Building green infrastructure such as green roofs is a way for cities to mitigate environmental stressors but these living systems will also be affected by extreme climate variation. The response of green roof plants to heat and drought is not well-documented and the effect of soil microbial communities on these plant responses is entirely unknown. Beneficial root-associated microbes, including arbuscular mycorrhizal (AM) fungi, which aid host plants under heat and drought stress, have been confirmed on urban green roofs. Understanding the response of green roof plants, microbes, and plant-microbe interactions to heat and drought is crucial for future urban climate change resiliency planning.

Project goals

This project seeks to characterize how different combinations of green roof plant species (*Panicum virgatum, Solidago nemoralis, Sedum tetractinum*) and root-associated microbial assemblages respond to isolated and simultaneous heat and drought treatments.

Hypotheses

(1) Plants inoculated with green roof soil will have greater percent root colonized with AM fungi than control pots

(2) Plants with AM fungal associations will have increased stomatal conductance (g_s) across a range of environmental conditions

Methods

(1) **Experimental design**: We explore how plant water relations are partitioned by soil type and environmental treatment. Soil microbial communities were established in greenhouse pots via inoculation with field-collected soil from conventional green roofs planted with *Sedum* and green roofs planted with mixed vegetation, and with green roof media autoclaved as a control. Plants undergo heat and drought treatment for one week.

(2) **Plant Ecophysiology**: stomatal conductance (g_s) and chlorophyll fluorescence will be measured to evaluate transpiration rates and plant stress. This will occur four days preceding, one week during, and four days after the treatments.

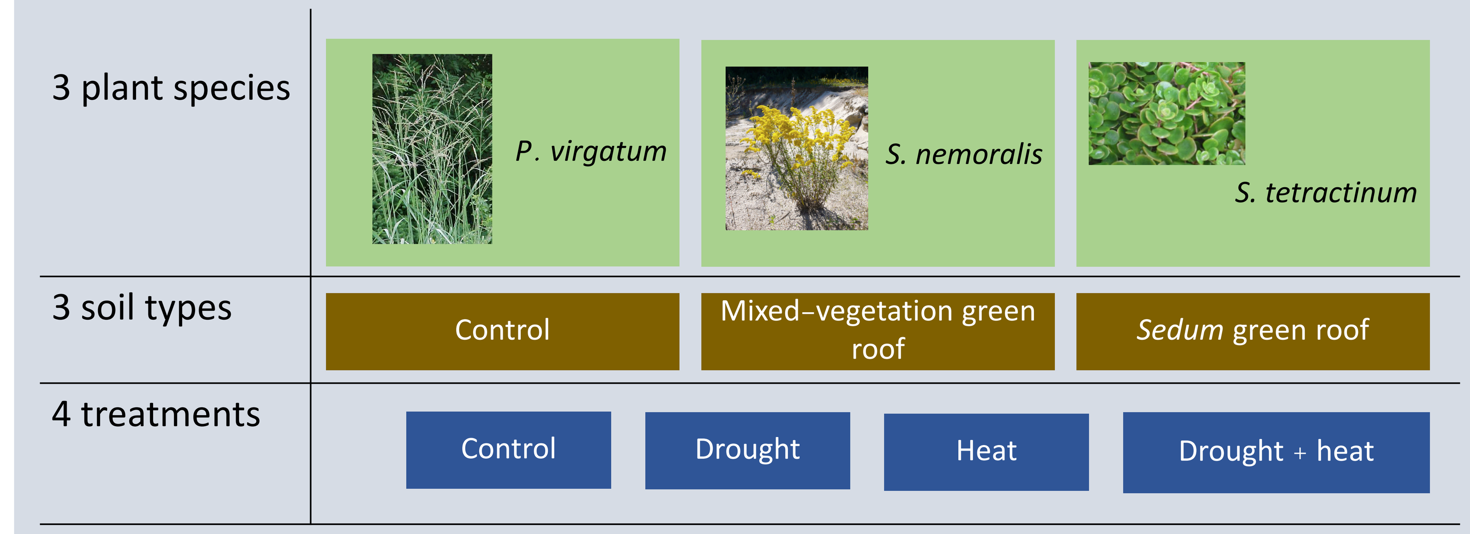

Figure 2: Experimental design schematic. This outlines the three plant species commonly grown on green roofs, three soil types, and four treatments that represent extreme environmental events resulting in 36 combinations of plant-soil type-environmental treatment.

Preliminary results

Between 10am-1pm, g_s was measured on a subset of plants one and two days after watering. *S. nemoralis* had the highest g_s followed by *P. virgatum* and *S. tetractinum* ($p<0.001$). All plant species had reduced g_s from day one to day two ($p<0.05$). Soil type was not significantly correlated with g_s by day or by species. However, gs for S. tetractinum on day two was correlated with soil type ($p<0.05$). Additionally, g_s was more strongly correlated with g_s for day two versus day one.

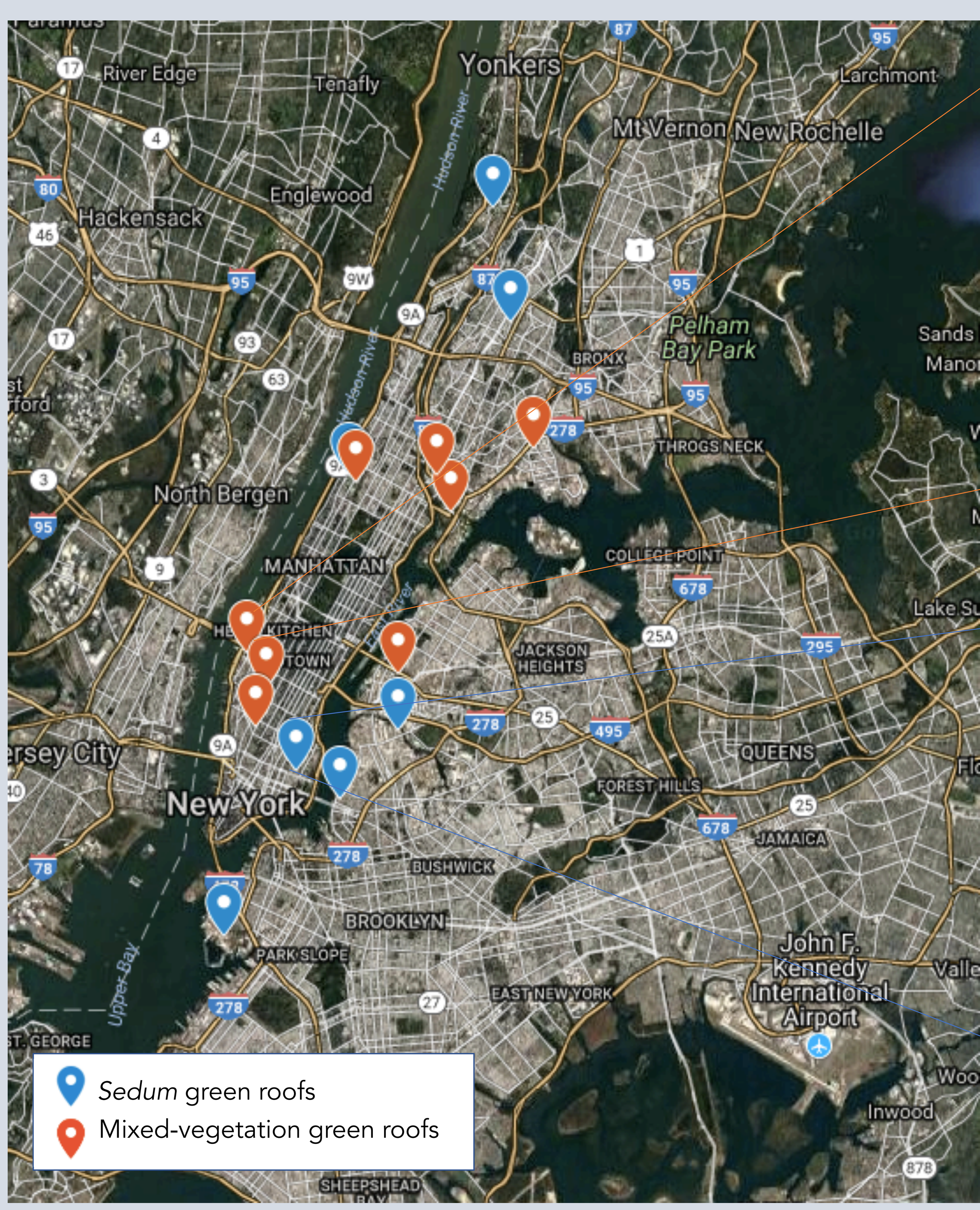

Figure 1A: Green roofs in NYC used as sites for field-collected inoculum. Red points indicate *Sedum* green roofs and blue points indicate roofs with mixed vegetation.

Figure 1B: Example of a conventional green roof planted with *Sedum* (Javits Center)

Figure 1C: Example of a green roof planted with mixed vegetation (Wild Project Theater)

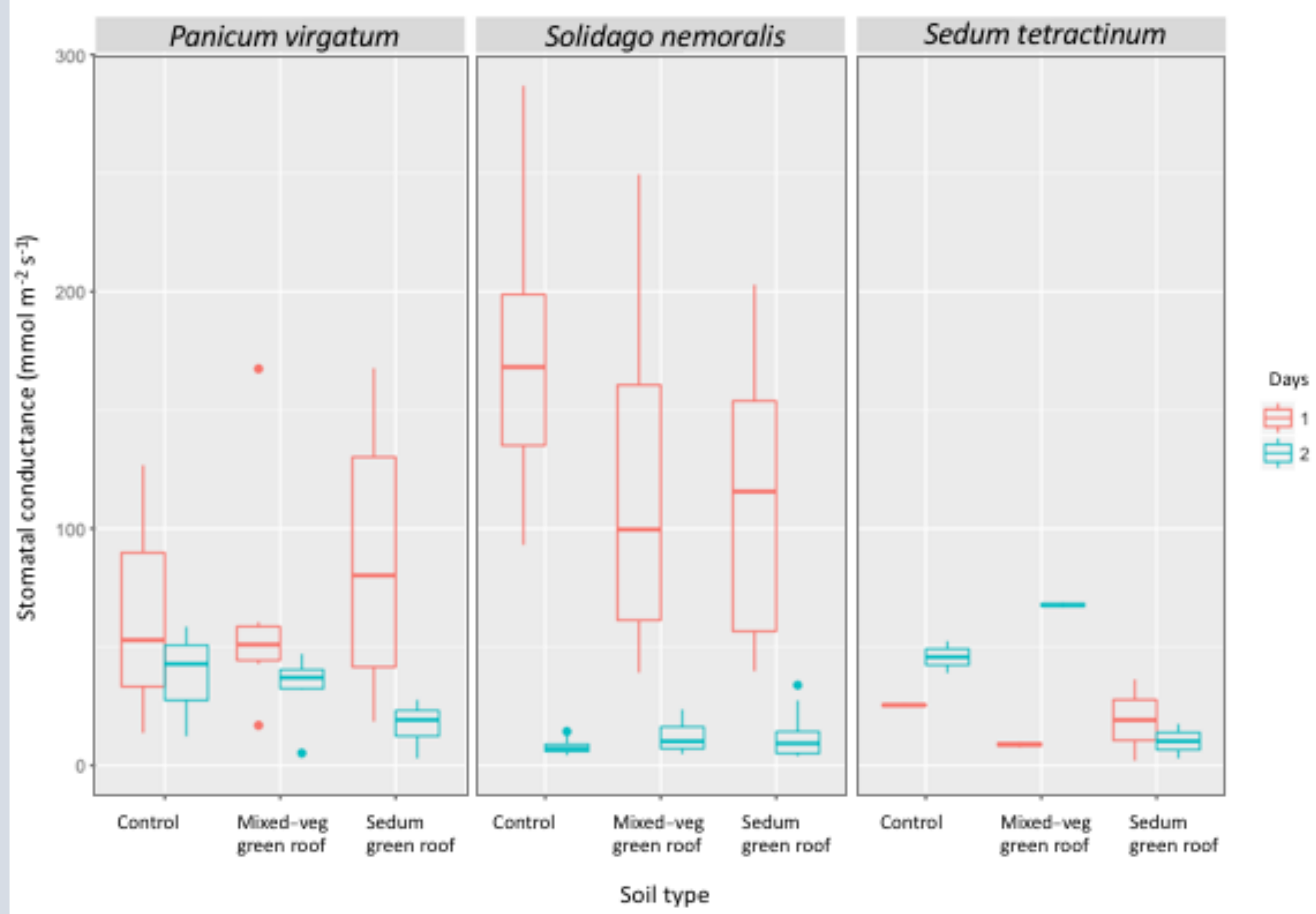

Figure 3: stomatal conductance (g_s) for *P. virgatum*, *S. nemoralis*, and *S. tetractinum* one day and two days after watering. Day 1 and day 2 measurements are indicated by the pink and blue boxes, respectively. Each panel is divided by the three soil types.

Literature cited

Augé, R. M. (2001). Water relations, drought and vesicular-arbuscular mycorrhizal symbiosis. *Mycorrhiza*, *11*(1), 3-42.

John, J., Kernaghan, G., & Lundholm, J. (2017). The potential for mycorrhizae to improve green roof function. *Urban Ecosystems*, *20*(1), 113-127

Oberndorfer, E., Lundholm, J., Bass, B., Coffman, R. R., Doshi, H., Dunnett, N., ... & Rowe, B. (2007). Green roofs as urban ecosystems: ecological structures, functions, and services. *BioScience*, *57*(10), 823-833.

Wu, Q. S., & Xia, R. X. (2006). Arbuscular mycorrhizal fungi influence growth, osmotic adjustment and photosynthesis of citrus under well-watered and water stress conditions. *Journal of plant physiology*, *163*(4), 417-425.

Impact

This project will allow us to explore green roof biotic community dynamics and their response to climatic events Information regarding how soil microbial communities, including functional groups such as AM fungi, respond to environmental conditions and subsequently influence plant ecophysiology, could contribute to urban climate change resiliency planning. We hope that this project will inform green roof management in the future.

Acknowledgements: thank you to green roof managers for your support (Ceci de Corral, Gwen Schantz, Max Lerner, Michelle Forcella, Kinsley Jabouin, Howie Waldman), my assistants/field team, Dr. Kevin Griffin for guidance on plant ecophys, Nick Gershberg for greenhouse management, and Camille Joseph and others at GNPC. This project was made possible with funding from the Javits Center, the Botanical Society of America, the Earth Institute, and E3B Department at Columbia.